Station Paper No. 62 January 1956

Influence of Loblolly Pine Overwood on Advance Reproduction

by

E. V. Brender and John C. Barber

SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina

E. L. Demmon,
Director

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

CONTENTS

= Pinus taeda L

INFLUENCE OF LOBLOLLY PINE OVERWOOD ON ADVANCE REPRODUCTION

By

E. V. Brender and John C. Barber

INTRODUCTION

At sporadic intervals, perhaps once each decade, a favorable combination of loblolly seed production and rainfall distribution occurs in the lower Piedmont region, with the result that pine seedling stands become established beneath overwood stands of loblolly pine. The majority of these understory pine stands are found on the flat ridge tops and on gentle to moderate slopes of southerly and westerly exposures. This advance reproduction occurs in more or less uniform age classes over contiguous areas from a few acres to as many as 100 acres, depending upon the uniformity of the topography.

The overstory stands may have a stocking of 120 square feet of basal area per acre and still have a solid understory stand of loblolly pine (fig. 1). Advance pine reproduction may also become established underneath stands as young as 20 years of age where the overwood is less than 60 square feet of basal area (fig. 2).

The occurrence of loblolly pine reproduction as an understory has great potential value to the landowner. He has only to give it reasonable care to insure the establishment of his future stand or parts of it. Regardless of the landowner's method of management, thousands of acres of seedlings become established in advance of the planned reproduction cut. This applies whether the stand is to be reproduced by leaving seed trees, or by the shelterwood method, or in openings created by selective cutting, or even where the plan specifies clear cutting and planting. Where this advance reproduction is present, the owner will not have to wait several years for the right combination of seedfall and rainfall, nor bear the expense of planting. In an effort to realize more fully the potential of this advance reproduction, a study was begun to determine the conditions under which these seedling stands become established and maintain themselves, and to determine the growth rates of the seedlings.

METHODS OF INVESTIGATION

The data were collected on and in the vicinity of the Hitchiti Experimental Forest, near Macon, Georgia, from 79 circular quarter-acre plots covering a range of loblolly pine overwood and understory conditions as follows:

Figure 1.--A stand of 8-year-old loblolly pine seedlings beneath an overwood of 120 square feet of basal area per acre.

Figure 2.--Stand of 5-year-old loblolly pine seedlings underneath a 22-year-old overwood of 60 square feet basal area.

Range of Plot Conditions

Overwood stand density	Stand density index (SDI) 23-298
Overwood stocking	12-158 sq. ft. basal area per acre
Overwood age	16-66 years
Overwood shade level	7-48 feet
Site index	36-92 feet at age 50
Average understory seedling ages	4-19 years
Average understory seedling heights	0.9-17.9 feet
Number of seedlings per acre	3,000-20,000

The appendix of this paper contains definition of SDI and conversion values of SDI to basal area.

All trees in the overstory of the quarter-acre plot were included to express degree of stocking. Five of the dominant or codominant trees on each plot were used to determine the age, site index, and average level of shade (height to base of live crown) of the overwood. Measurements of the pine understory were taken on alternate milacre quadrats extending in the four cardinal directions from the center of the quarter-acre plot. The understory data included age of seedlings, total height of dominant seedlings, degree of stocking, and seedling form.

This report first considers changes in the development of the overwood; then it deals with static relationships of advance reproduction under undisturbed conditions; and, finally, the more dynamic relationships in a growing forest are considered.

DEVELOPMENT OF THE OVERWOOD

Changes in Stocking

The annual rate of increase in SDI, or in basal area, depends principally upon the site, the degree of stocking, and to a lesser extent upon the age of the stand. The arithmetic average annual rate of growth for the average site with an index of 70 was found to be 4.5 SDI units, or 2.25 square feet of basal area per acre in stands which averaged 142 in SDI and 75 square feet in basal area at the outset of the 5-year measurement period. However, as we shall see later, the annual changes in SDI exert a relatively small influence upon the rate of development of the understory pine seedlings.

Changes in Crown Ratios and Levels of Shade

An important relationship of age and stand density to crown ratio of dominant and codominant trees was established in this study. The relationship is expressed by the following regression equation: 1/

$$\text{Crown ratio} = 91.61 - 0.0685(\text{SDI}) - 0.8068(\text{age})$$

where

crown ratio = percent of live crown of the average dominant and codominant trees

SDI = stand density index

age = age of overwood

For each 10-year advance in age the crown ratio is reduced by 8 percent, while the estimated effect of increase in stand density during that period amounts to an additional average reduction in crown ratio of about 3 percent. This reduction results in raising the shade level of dominant and codominant trees. By applying the crown ratio values obtained from the equation to the average total height of dominant and codominant trees, and subtracting the resultant crown length from the total height, the principal level of shade of a stand can also be determined. Figure 3A and B shows the changes in crown ratio with age and density, and the corresponding changes in levels of shade on average sites. For example, the dominant and codominant trees in a 20-year-old open-grown stand of 40 SDI would have an average crown ratio of 73 percent. Ten years later at an SDI of 85, the average crown ratio would be 62 percent. The corresponding levels of shade would be 11 and 21 feet, respectively.

SURVIVAL AND GROWTH OF UNDERSTORY PINE

Survival and growth of advance pine reproduction depend upon the amount of overwood present and upon its level of shade.

Influence of Overwood Density

The influence which the overwood density exerts upon the development of advance pine reproduction varies for different seedling age classes. It is least important with young seedlings, but with older reproduction the influence of overwood density becomes increasingly important. For example, for 4-year-old seedlings a difference of 160 SDI units in overwood stocking is required to produce a difference of 1 foot in seedling height, while for 10-year-old seedlings only 36 SDI units are needed to produce the same difference.

Influence of Level of Shade of Overwood

The influence of overwood density on seedling behavior is only part of the story; of even greater importance is the level of shade of the overwood,

---

1/ See Appendix for analysis of variance of independent variables.

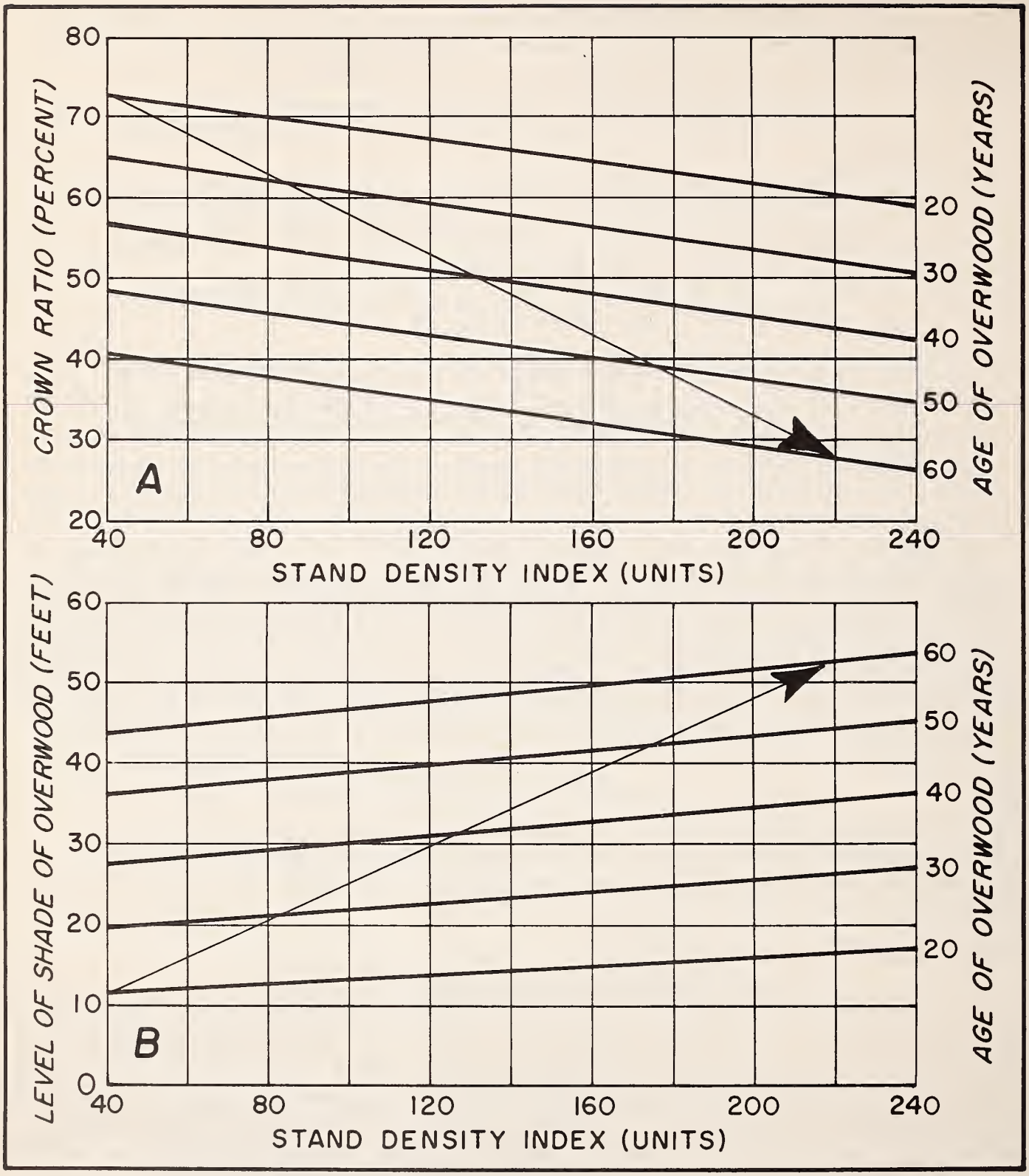

Figure 3.--The proportion of live crown of dominant and codominant loblolly pine trees, and the height to the base of their crowns depend upon their age and the stand density. This relationship at any given time, as determined by this study, is shown by the five parallel lines in these charts. With elapsed time, the change to be expected in crown ratio is shown by the arrow in chart A. The simultaneous change in shade level in the opposite direction is shown by the arrow in chart B.

as measured by the height to base of live crown. Survival and growth of the understory pine seedlings are poorest under low overwood shade. For instance, with a low shade level of 10 feet, well-stocked 4-year-old seedling stands were not found when the overwood SDI exceeded 140 units. With a high shade level of 40 feet, 4-year-old seedling stands were observed under an SDI of 300 units. Shade level also strongly influences understory seedling heights. For every 10-foot increase in level of shade, average seedling height is 0.7 foot greater.

Combined Effects of Overwood Density and Shade Level

The total effects of overwood density, level of shade, and seedling age can be expressed by the following equation: 2/

$$\text{Seedling height} = -4.9607 + 1.4620(\text{age}) + 0.0079(\text{SDI}) + 0.0696(\text{shade}) - 0.0036(\text{age})(\text{SDI})$$

where

seedling height is expressed in feet

age = age of understory in years

SDI = stand density index

shade = height of shade of the average lower limit of the crowns of dominant and codominant trees expressed in feet above ground.

A relatively small amount of overwood exerts a depressing effect on the height growth of understory seedlings. Even under a high shade level of 40 feet and an overwood density of only 40 SDI units, the average height of 4-year-old seedlings is only 63 percent that of free-growing seedlings. But, it takes a large increase in overwood density to bring about additional noteworthy reduction in seedling height growth. Even when the overwood density is 120 SDI units, the average 4-year-old seedling is still 52 percent as tall as a free-growing seedling (fig. 4A).

When comparing seedling heights attained under lower overwood shade levels with the height of free-growing seedlings, the contrast becomes progressively larger. For example, 4-year-old seedlings under a 20-foot shade level and under a stand of SDI 40 are only 38 percent as tall as free-growing seedlings (fig. 4B).

The survival of understory pine stands, as influenced by shade level and stand density, is also shown in these graphs. Under a low shade of 20 feet, and an overwood density of 220 SDI, no seedling stands above 6 years of age were encountered in this study; but with a high shade level of 40 feet, even 10-year-old seedling stands can maintain themselves under the above degree of stocking.

2/ See Appendix for analysis of variance of independent variables.

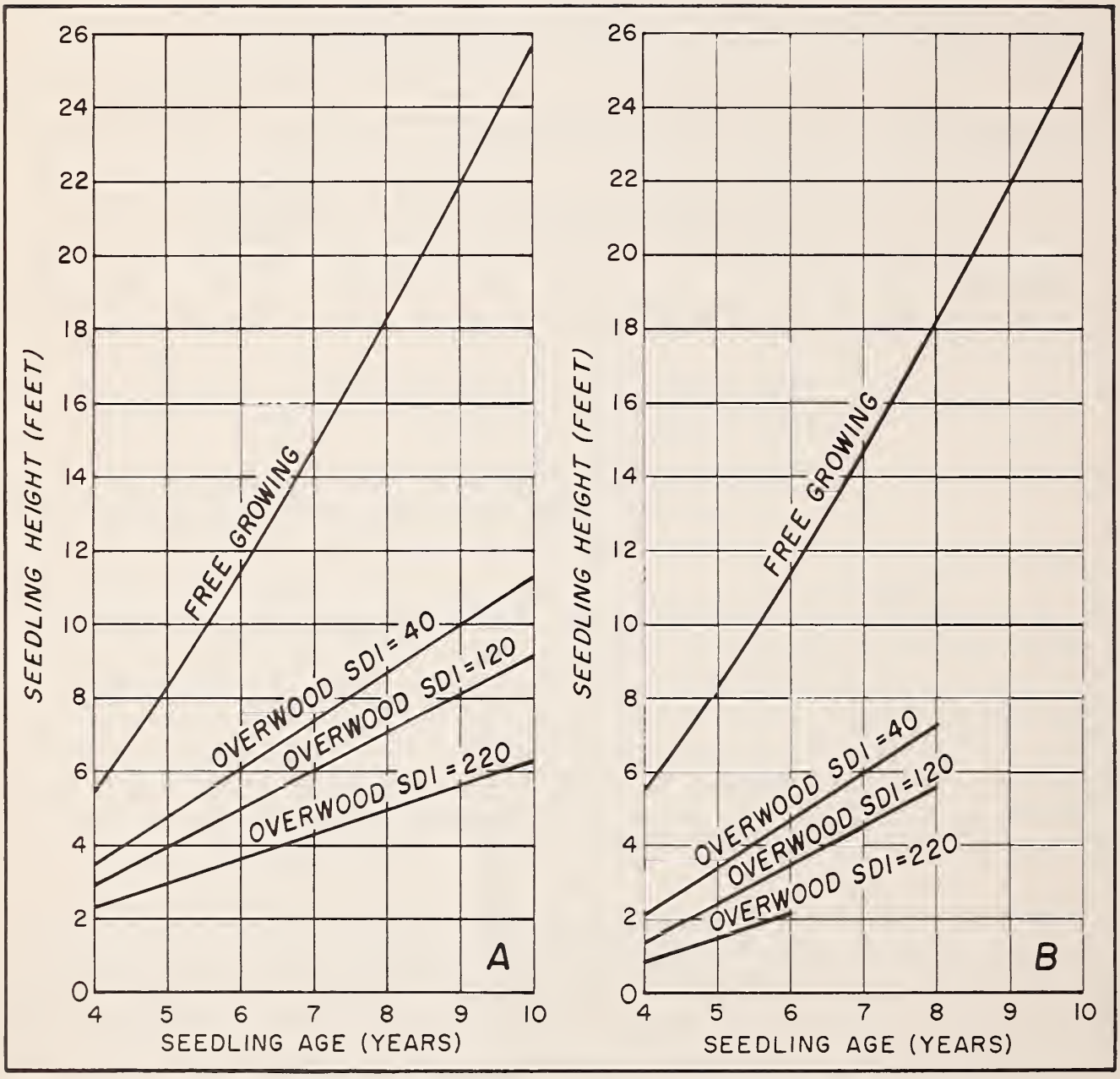

Figure 4.--Comparison of understory seedling heights at various ages and overwood densities with that of free-growing seedlings. A, At a high (40-foot) shade level. B, At a low (20-foot) shade level.

Concurrent Overwood and Understory Development

The information presented to this point has dealt with static forest conditions. In a growing forest, changes occur in the stand density of the overwood, in its level of shade, in the age of the understory seedlings, and the reaction of the seedlings to these changes.

Under average conditions, the overwood of loblolly pine stands in the lower Piedmont increases annually about 4.5 SDI units and the level of shade is raised about 1 foot. This annual rise in shade level, which is a favorable factor in understory seedling development, usually compensates, or more than compensates, for the influence of annual increase in overwood density. The development of advance pine reproduction in a given stand can be projected by inserting new values for progressive changes in the overwood and age of the understory seedlings in the formula developed for seedling heights.

This has been done in figure 5 for seedlings which originated under relatively high shade levels associated with a 50-year-old overwood at different initial degrees of stocking and an initial understory seedling age of 4 years.

In figure 5, where the density of the overwood was increased 27 SDI units and the shade level was raised 6 feet, the height growth of understory seedlings during the 6-year interval was 7.6, 5.8, and 3.7 feet with initial densities of 40, 120, and 220 SDI units respectively.

CONCLUSIONS

In the lower Piedmont, fully-stocked stands of advance reproduction survive and grow underneath a great range of overwood densities of loblolly pine. A relatively small amount of overwood markedly reduces the height growth of understory seedlings as compared with that of free-growing seedlings; but a rather large additional increase in overwood density is required to bring about significant additional reduction in seedling height growth. Thus, under the shelterwood method of regeneration, considerable leeway can be exercised in the amount of overwood left.

This study shows that level of shade ranks with overwood density as a major factor affecting the growth rate of loblolly pine seedlings. In fact, in a given stand, the progressive increase in shade level over a period of time has more effect on the growth rate of young seedlings than has the simultaneous increase in overwood density.

By cutting the limby, low-shade-level trees in thinnings and improvement cuttings, the average level of shade can be raised promptly. In addition, natural pruning, by virtue of increased age of the overstory trees, further raises the level of shade, which is a favorable factor in seedling survival and height growth. Where hardwood invasion is not a serious problem, relatively young open-grown stands of loblolly pine can be regenerated in the lower Piedmont by the shelterwood method without additional cultural measures, as soon as the overstory bears a good crop of seed. Early pruning in such open-grown stands would serve the dual purpose of improving the quality of the product and improving the environment for regenerating a new stand.

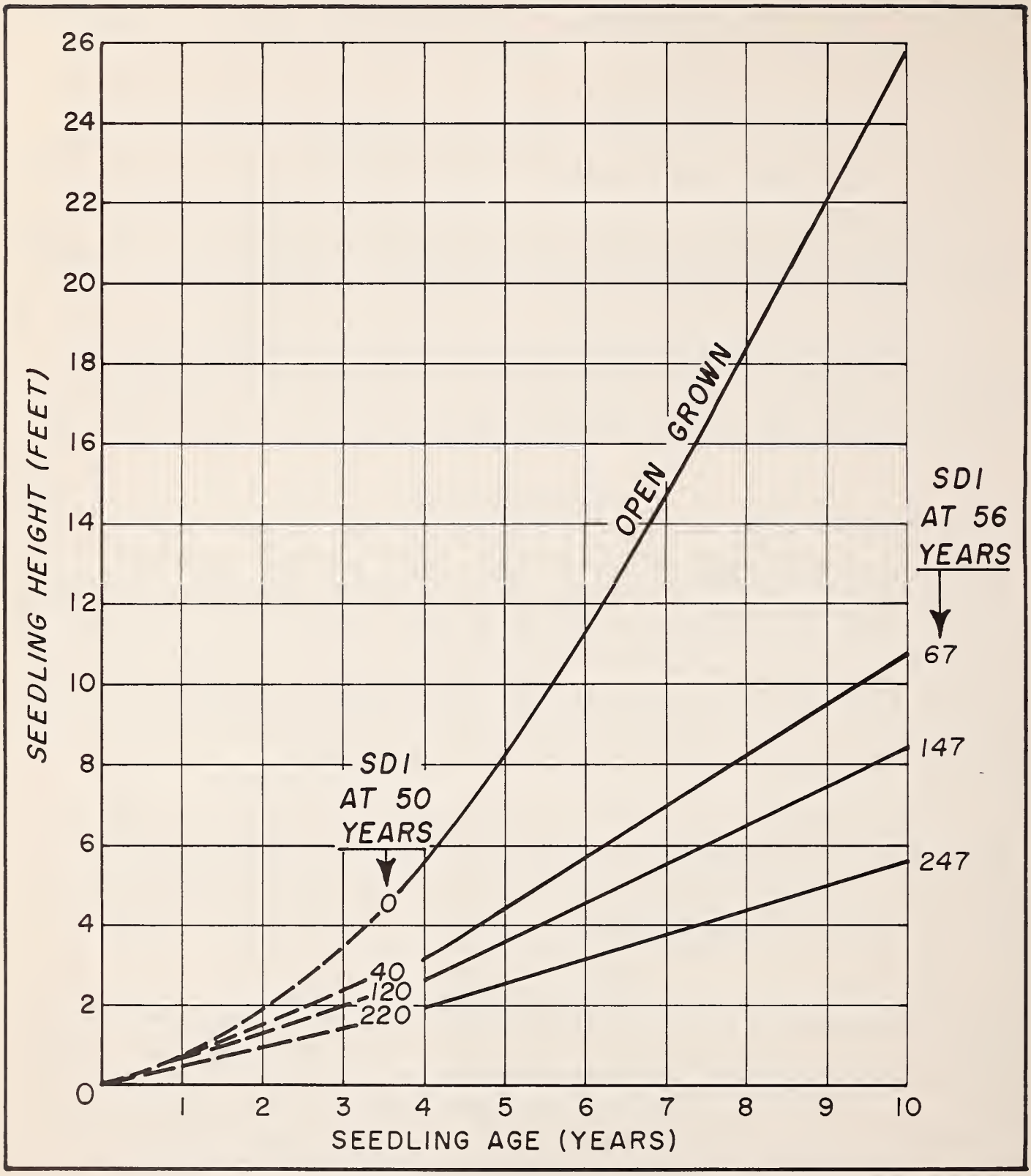

Figure 5.--Forecast of seedling height development in relation to progressive natural changes in a 50- to 60-year-old overwood at initial densities as shown on the chart and with a rise in shade level from 36 to 42 feet between 4 and 10 years.

APPENDIX

Stand Density Index

Stand density index, developed by Reineke, [3/] is a measure of the relative density of a stand. It is based on a logarithmic equation which evaluates number of trees per acre and average size of the individual tree. The index value is equal to the theoretical number of trees 10 inches d.b.h. which would be the equivalent stocking.

The set of factors below has been computed to determine the conversion values from SDI to basal area and vice versa.

Basal area in square feet = SDI x factor

Stand density index = basal area ÷ factor

Average d.b.h. of stand (Inches)	Factor for converting SDI to basal area	Average d.b.h. of stand (Inches)	Factor for converting SDI to basal area
6	0.445	13	0.605
7	.473	14	.623
8	.499	15	.640
9	.524	16	.657
10	.545	17	.673
11	.567	18	.688
12	.586	19	.703
		20	.717

Crown Ratio

The following equation was developed to express crown ratio of loblolly pine in undisturbed stands:

Crown ratio (%) = 91.61 - 0.0685(SDI) - 0.8068(age)

where

SDI = stand density index

and

age = age of overwood in years.

3/ Reineke, L. H. Perfecting a stand-density index for even-aged stands. Jour. Agr. Research 46(7): 627-638. 1933.

The independent variables were tested by analysis of variance as follows:

Source	d.f.	s.s.	m.s.	"F"
Effect of SDI	1	0.083738	-	19.03**
Added effect of age	1	.463225	-	105.28**
Residuals (error)	50	.220018	0.004400	
Total	52	.766981		

Seedling Height

The following equation was developed to express seedling height:

Seedling height (feet) = -4.9607 + 1.4620(age) + 0.0079(SDI) + 0.0696(shade level) - 0.0036(age)(SDI)

where

age = age of seedling in years

SDI = stand density index of overwood

and

shade level = height (feet) to base of live crown of overwood.

The independent variables were tested by analysis of variance as follows:

Source	d.f.	s.s.	m.s.	"F"
Effect of age	1	6.558019	-	484.**
Added effect of SDI	1	.229965	-	16.99**
Added effect of shade	1	.262082	-	19.36**
Added effect of (age)(SDI)	1	.145632	-	10.76**
Total due to regression	4	7.195698		
Residuals (error)	74	1.001751	0.013537	
Total	78	8.197449		

** Indicates significance at the 1-percent level.

Agriculture-Asheville

Missing: 63